INTERNATIONAL HELLENIC UNIVERSITY

Prediction Currency Exchange

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SID:3301140006

SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of

Master of Science (MSc) in Information and Communication Systems

JANUARY 2015

THESSALONIKI – GREECE

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Abstract

Since the mid-twentieth century, oil is one of the key indicators of global economic activity, because of the overriding importance of the supply of world energy requirements. Despite the emergence of alternative forms of energy (such as wind and solar), oil remains the main source of energy. Therefore, it is assumed as one of the major factors that regulate the proper function of the global economy. It is a strategic product especially for large countries, which seek to ensure the smooth flow. The price of oil, like the price of all commodities, is shaped by the forces of supply and demand while it is influenced by a multitude of geopolitical and other factors.

The fluctuation in oil prices affect the economic and social life, so it is one of the issues that concern all citizens and many researchers who study the effects that oil prices in the sizes of macroeconomics.

The precious yellow metal, gold, the last decades is for investors a safe investment "*retreat*" for their funds, since there is a common perception that yields operate compensation compared to inflation, the depreciation of the dollar exchange rate, stock index returns and other investment assets especially in times of economic crisis and political unrest.

The relationship between macroeconomic variables, gold price and oil price fluctuations has been extensively analyzed in the literature, especially during the last three decades. Many researchers have concluded that there is either a negative or a positive correlation between the increases in oil and gold prices and the economy. Fluctuations in gold and oil prices, as it is proved by the analysis affect the aggregates that interest rates, inflation, the exchange rate and the growth rate of the Eurozone.

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Introduction

Initially, the study focuses on the history and the valuable role played by the oil and gold to mankind since ancient times until today. Subsequently, an analysis of the forces of supply and demand on the gold and oil market presents the key factors affecting their prices.

The objective of the study is not limited to theoretical approach of the market analysis of the oil and gold. This research is a study of the behavior of returns of gold and oil on the exchange rate of EUR/USD. More specifically, it is examined the existence of correlation between the price of oil and gold to the values of exchange rate of euro against the dollar.

The empirical approach is performed using the regression model with maximum likelihood under heteroscedasticity GARCH, and asymmetric variants, TGARCH models and EGARCH models to consider the asymmetry of returns of investment assets on the positive and negative disorders (shock) in the economy. Furthermore, we are going to use Granger Causality in order to identify the existence or the absence of a correlation between the aforementioned factors.

Chapter 1

1. Introduction to Stock Exchange Market

The stock markets are peculiar to the notion of the simultaneous meeting of the supply and demand. They are an economic institution which is, in generally, recognized by the countries where they are established and the majority of them with legislative and administrative measures define the context in which markets are formed and establish the conditions and their terms of service. Stock markets are divided into Securities Stock Markets, Commodity Stock Markets and Freight Stock Markets.

Nowadays, the stock markets are essential institutions for the economic system of the West. In the rich economies of the world, someone can find the most developed capital markets which are usually based on a stock exchange market such as these of New York (Wall Street and NASDAQ), of London, Paris or Frankfurt.

The stock market is an organized market through which the interested parts can find each other in order to carry out purchases and sales of securities (such as shares of capital of limited companies, bank products, government or other kind of bonds) and/or goods. The difference between the stock market and the other forms of markets that we know (street markets, shops) is that an exchange of stock products is not conducted because it is necessary (to eat, be clothed etc.), but it is conducted for profit reasons.

Another difference is that the transactions in stock markets are not made directly between those participating but through the stock brokers who execute orders in exchange for services to withhold any commission.

Most exchange markets are established on a physical space, such as Athens Stock Exchange Market (http://www.ase.gr) or the New York Stock Exchange Market (http://www.nyse.com). However, there are stock exchange markets in which transactions are made through a network of telephones and computers.

Example of such an electronic stock exchange market is the NASDAQ (http://www.nasdaq.com) in the United States, involving more than 5,000 companies. Among these is the one with the largest capitalization than any other in the world, this of Microsoft.

1.1. Reasons for their Creation

The stock exchange markets had been created for the finding of short-term but especially long-term funds and the need to conclude purchases and sales of large quantities of goods at remote place of their trading, while there was the need for serious funds and the trend for speculation.

Their organized form is the result from:

- ✓ The transactions' carrying speed.
- ✓ Their immediacy.
- ✓ The publicity of the transactions which appear publicly all their special characteristics (supply, demand, quantity and value).
- ✓ The purity of the transaction.

1.2. The Importance and their Role

The economic role of the Exchanges is to:

- ✓ facilitate trade, because they allow representatives of supply and demand to be together in this trading venue,
- ✓ allow the free pricing of goods on the basis of fundamental law of supply and demand. In this way the risk of creating artificial prices is limited,
- ✓ give the opportunity for enterprises to obtain capital and for the investors to allocate the money to the investment for their titles, with the expectation of profit, thus helping to boosting productivity and more generally to the development of the country operates the stock market.

The current stock exchange markets have their roots in organized antiquated markets, where traders gather to buy and sell goods. Later in Rome such transactions were conducted in Collegiae Mercatorum and during the Middle Ages in fairs. Over the years, since the number of goods was increasing, standing business reports were established without the existence of the transaction objects.

Some years later, various trade papers appeared (bills, foreign exchange, equities, bonds) and need of the traders to meet at a specific place and time every day became the greatest.

On the other hand the quantities of objects that are traded from the interested parties were great and so the stock split into categories depending on their subject matter.

Today there exist:

- ✓ Stock Exchanges (which are trading securities).
- ✓ Commodity Exchanges.
- ✓ Freight Exchanges.
- ✓ Flower exchanges, etc

The stock markets depending on how the establishment and operation are, are divided into official and free:

- ✓ *Official Exchanges*.

These are set up and controlled by the State, which approves the statutes and regulations and work under direct supervision. Most stock exchanges operating nowadays in Europe are official.

- ✓ *Free Exchanges*.

These are set up and operated by a private initiative of the same companies and the state does not intervene at all in the body nor exercise any supervision.

The first stock exchange in its actual sense had started its operations in the mid-15th century and was in Antwerp. It obtained a mixed character, being at the same time stock exchange and commodities exchange.

2. Introduction to the Exchange Rate

The exchange rate is a major determinant of exports and competitiveness of an economy. A highly important macroeconomic rate which can determine the exchange rate and the demand of net exports is the domestic product or domestic income.

As the consumers' expenses depend partially on their income, when the domestic income increases, then the consumers will increase their spending on goods, including imports. Therefore, net exports will be reduced, since other factors held constant.

However, the residents of the country in order to acquire foreign goods, exchange the domestic currency with currencies of other countries. Consequently, there is induced an increase on the supply of the domestic currency, leading to depreciation (Krugman and Wells, 2009). Conversely, an increase on the income of the foreign trading partners, push foreign consumers to increase their spending on goods and services, including the domestic ones.

In this case, foreign consumers are forced to exchange their currency to the domestic, in order to acquire domestic goods, causing an increase in the demand of the domestic currency and hence its appreciation (Karfakis, 2008).

The second most important determining factor of macroeconomic exchange rate and net export demand is the real rate, which when increases as the other factors remain stable, makes the financial assets of the country attractive to foreign savers who seek the highest return on their capital. For the acquisition, however, of domestic assets it is required in principle to acquire domestic currency.

Therefore, the increase of the domestic real interest rate causes increased demand for the domestic currency and hence appreciation. In contrast with the domestic income, real interest rate does not affect directly, but indirectly net exports, as domestic exports become more expensive due to the increased exchange rate. The result will be the opposite if the foreign real interest rate increases. Domestic savers will turn to foreign financial assets by exchanging domestic currency with foreign, causing thereby increase in the supply and therefore depreciation. This fact makes exports cheaper in the domestic economy and therefore causes an increase in net exports (Tsagaraki, 2010).

During a crisis, according to Marcin Kolasa, Michał Rubaszek and Daria Taglioni (2010), who reviewed the performance of Polish business during the crisis, they concluded that the performance of Polish companies seems to have worsened from the hustle of the global crisis in the mid-2008. They argue that the devaluation, which caused by the crisis may have strengthened the international competitiveness of Polish enterprises, yet at the same time can result in higher leverage on companies with debt denominated in foreign currency. The highest leverage, in combination with tight financial markets, could constrain domestic companies in their access to the financial markets, both for finance new investment opportunities and also in terms of trade credits availability.

Rupa Duttagupta and Antonio Spilimbergo (2004) argued that, according with their research on the effects of the 1997's crisis in Asia and its exports, the empirical results showed that exports of Asia increased slightly, despite the depreciation caused by the appearance of crisis. Furthermore, Rupa Duttagupta and Antonio Spilimbergo conclude that the exports in the first two years of the crisis deteriorated significantly and after this period of time began to recover and try to reach the levels before the crisis. In other words, initially exports decline – during the first period of recession - and then enjoy strong growth, as it is the tool with which a country will try to overcome the crisis. At the same statements concluded, also, Prema-Chandra Athukorala (2006), who studied the behavior of the Indonesian exports before and after the crisis.

3. The Impact of Oil Prices on the Macroeconomic Indexes

Oil prices are a key driver of global economic performance. Higher prices may cause serious damage to the global economy, particularly to the economies of oil - importing countries, such as European countries. Half of the European Union's energy requirements are imported and according to a European Commission study (2001) the dependence on external energy sources is expected to increase significantly over the coming decades, approximately 70% in 2030. This fact implies that the European economy is affected by potential increases in oil prices. For example, the geopolitical instability in the Middle East can change the world oil market, which in turn will greatly affect Europe, as happened with the 1970's oil crisis.

The increase in oil prices leads to a transfer of income from importing countries to exporting countries through the changes in the terms of trade. The greater the increase in oil prices and the longer the rise in prices are, the greater the macroeconomic impact is. When referring to exporting countries, a rise in prices directly leads to an increase in real national income through the higher export earnings. Higher oil prices lead to inflation, rising production costs and declining oil demand. Tax revenues reduce and the deficit in budget increases, due to the inflexibility of the government spending, which drive the interest rates upwards. The increase in oil prices generally lead to upward pressure on nominal wages and higher unemployment, at least in the short term. In addition, the aforementioned changes the balance of trade between countries. The oil-importing countries normally face deterioration in their balance of payments, pushing negatively the exchange rates. As a result, imports become more expensive leading to a drop in the real national income.

Bruno and Sachs (1985) were the first who analyzed in depth the impact of oil prices on the production levels and the economic growth in major industrial countries. Using data from 1970 they analyzed issues such as the role of the oil shock, the monetary policy and the wage formation.

Moreover, Gisser and Goodwin (1986) examined the causal relationship between oil prices and four macroeconomic indicators (real GDP, real investment, unemployment and general price level). They concluded that oil prices influence the future course of the four indicators.

The negative correlation between the increase in oil prices and the economy (in general) was confirmed by Mork (1989) for the period 1948-1988.

Cunado and de Grazia (2005) studied the effects of oil shocks on inflation and economic growth for the period 1975-2002 in order to examine the relationship between oil prices and the macroeconomics. They found by using non-linear models (nonlinear specifications) that the oil shocks affect both the inflation and the growth rates of countries.

Darby (1982) was the first to study the macroeconomic impact of the oil crisis of 1973-4 in OECD countries.

Cunado and de Gracia (2003) found that the increases in oil prices have a significant impact on both the inflation and the growth in the Greek economy. In a more recent study, DeMiguel et al. (2003) found that in southern European countries (Portugal, Spain, Italy, Greece) had been observed the highest negative impact in the European Union on GDP due to the abrupt changes in the price of oil, with a maximum effect in Greece. Studying the oil crises of the 1970's and 1980's, they also identified the greatest losses in prosperity in Greece and Portugal, 7.9% and 8.1% of GDP respectively.

Hamilton (1983) using data from 1950-1980 covering both oil crises (1973 and 1979) concluded that there is a relationship between oil prices and the economic downturn and particularly the oil price shocks causes recession. According to Hamilton, all recessions in the US economy caused by a sharp increase in oil prices. High oil prices lead to a decrease in oil supply, and reduce global production. Moreover, it was noted that oil price fluctuations had had strong negative effects on oil-importing countries and that the impact of oil price increases become more evident in the economy after 3 or 4 quarters.

Hooker (1996) through his research on the oil price and GDP ratio, concluded that the oil crisis of 1979-1980 had a profound impact on macroeconomic fundamentals of the economy.

Burdidge and Harrison (1984) investigated by implementing the VAR method the relationship between oil prices and economy in 5 countries (US, UK, Canada, Japan, Germany), noting that oil price fluctuations affected the industrial production.

Lee et al. (1995) through their research concluded that the sharp increases in oil prices affect the economy.

Finally, Federer (1996) through his research found that changes in oil prices (increase/decrease) and their variability have a significant impact on economic activity both directly and after 1 year.

4. The Impact of Gold Prices

Many analysts believe that the price of gold is determined and influenced by a number of factors such as the production capacity of the mines, demand for processing of metal and the amount of scrap that is recycled. However, the biggest change in metal prices caused by demand for investment purposes.

Investors make in the metal market in order to offset the risk that arises in times of economic, political and monetary crises. Investors also buy gold to diversify their portfolios as there is a perception that natural assets (goods) that, contrary to financial investment instruments are the best way to hedge against recession and inflation (Wang et al. 2011).

4.1. The Impact of Gold Prices on the US Dollar

The literature identified a large number of assets relevant to the gold market. The value of the US dollar is a key factor in this market. During 2004, as the dollar fell against major currencies, gold prices scored record 15-years highs combined with the uncertain economic situation. The devaluation of the dollar and the possibility of a greater depreciation of the currency strengthen investment demand for gold. A weaker dollar increases the attractiveness of gold for safe investments (Tully and Lucey, 2006).

There is an inverse relationship between changes of gold and the US dollar value indicating the trend towards speculation in the lining of metal (Baker and Tassel, 1985; Levin and Wright 2006). Gold was a great compensation factor to the dollar in the last thirty years (Capie et al. 2005).

4.2. The Impact of Gold Prices on the Exchange Rate

Along with the dollar, the exchange rates between major currencies seem to exert influence on the gold price. The dollar, the euro, the pound sterling and the Japanese yen are the major currencies including the exchange rate affect the price of gold. Especially in the long run the relationship between exchange rates and the price of gold appears very considerable (Dooley et al. 1995).

The collapse of the fixed exchange rate system, which led to fluctuating exchange rates, has exacerbated the instability in the global gold market (Sjaastad and Scacciavillani 1996).

4.3. The Impact of Gold Prices on the Stock Exchange Markets

Equity prices and other speculative financial instruments are determining factors in the price of gold. In rising stock markets, investors are turning their investing interest in the shares. On the other hand, in declining markets investing in gold is more attractive thus the demand and the price of the metal rise (Koytsoyiannis, 1983).

Gold in global crises and increased credit risk is a haven for many equity markets. The performance of the metal reacts positively to negative shock of the economy in times of uncertainty. (Levin and Wright, 2006; Baur and Lucey, 2010; Baur and McDermott, 2010).

4.4. The Impact of Gold Prices on the Price of Crude Oil

The price of oil showed a long-term correlation with the gold price in the past. The price of oil affects the revenues of OPEC countries and inflation in the countries that are dependent on oil imports. The increase in oil prices affects inflation countries and therefore leads to an increase in demand for gold (Koutsoyiannis, 1983).

However more recent research shows that the relationship between oil and gold is weak and unbalanced. Yields of gold partially linked to the yields of oil as oil shows greater volatility in precious metal (Sari et al. 2010).

Chapter 2

1. Factors which Affect the Currency Exchange Rates

The exchange rate is one of the main determining factors for an economy, fact which is demonstrated from its anticipations and consideration of a basic concern of a state. The forecast of the exchange rates is essential to applying financial management on topics such as investments, short term hedging, extension activity abroad, location production etc.

For someone to look up in the past in order to predict the evolution of exchange rates is something that will lead to arbitrarily and incorrect conclusions. The level and the fluctuations of the exchange rates, since they are the major economic issue of a country, because of their strong impact, make their examination, as an utmost importance. One necessary element of this process is the finding of the factors affecting the exchange rates and their investigation, according to the prevailing socio-economic conditions, domestically and internationally.

One basic condition, except from the familiarity with the determinant factors behind the movements of the exchange rates, is the deep knowledge of the developments in the foreign exchange market. Today, the capital flows have been released in most states, giving the baton of identifying exchange rates, in the prevailing market forces, ie supply and demand for currencies. These forces are tailored to meet public expectations and socio-political developments in each state.

The situation in the aggregate indexes of a country, and the developments presented to them, are connected, according to analysts, inextricably linked to the course of exchange rates. They are considered the most critical factors affecting the exchange rate, due to the increased sensitivity to variability, while macroeconomic variables can only offer limited predictability of the exchange rate, in the short term.

The macro-economic factors such as the interest rates, supply and demand of money, the gross domestic product, the current account is some of the factors that alter and define appropriately the exchange rates. For example, the econometric model «*from general to specific approach*» shows that the interest rates and the money supply are the main forces influencing the exchanges rates.

The exchange market is not only concerned with the present state of the aggregates of a country and their future evolution. As a result, the investors and any other interested parties are obliged to examine every announcement about them, if it refers to an irreversible condition or a periodic phenomenon, and which changes will this bring.

Each case is unique and the duration of every change identifies the current movements and the future investors - traders. Changes in macroeconomic indexes almost always cause reactions and policies pursued by the authorities of a country. However, since, the macroeconomic indexes are published, the forecasting process based on them, is impossible.

For the specification of the exchange rates, the following are necessary:

- ✓ *Socio - economic conditions.*

These agents are capable of causing an increase in demand for foreign currency transactions, leading to decrease in the value of the domestic currency.

- ✓ *Inflation.*

In case the inflation rate is high, it implies that this country has reduced demand for the national currency compared to the other countries.

- ✓ *Offered products / services of foreign states.*

The offered products which are not available domestically will lead to an increase in the exchange rate since the demand for foreign currency will rise.

- ✓ *Balance of payments - Deficit*

The balance of payments of a country includes the financial transactions made in certain period of time between itself and other countries, and the account balance funds. In order to understand the phenomenon of the deficit in the balance payment, it is preferable to put an example.

The existence of deficit suggests a greater outflow of € by Greece over a period of one year, than the inflow for the same coin from foreign countries. As the level increases in the Euro selling exchange market, the value decreases in it, thus raising, the value of other monetary units, besides the expected. At this point, the State intervention appears, in order to balance the price. The actions of the governments include in such cases, the sale of their national currencies (to "*drop*" their value) and buying euros.

- ✓ *Actions from the State and the Central Bank*

The interventional action involves the currency exchange, in order to balance the value of the currency. Central banks implement foreign exchange policy, using its reserves in foreign currency to alter the value of the domestic currency.

- ✓ *News from the Central Banks / Information*

Someone should be aware of that sometimes, information related to the macroeconomic indicators, can have different impact on the exchange rate, depending on the period communicated and the prevailing conditions. Also of particular importance is the interpretation which will be yield from the market in those announcements, especially if this is based on the public expectations. For example, an announcement for the enlarging of the interest rate difference can be translated as an increase in the domestic level interest rates or a reduction in that of foreigners.

- ✓ The exchange rate can be seen as a function of the expectations of buyers and investors regarding the development of the price of national currencies and their exchange rates (rise - fall). The influence exerted to investment, speculative and commercial movements of the public expectations, results ultimately to a change in exchange rates.

Frenkel (1976), Mussa (1976) and Messe / Rogoff (1983) argue that the macroeconomic indexes such as inflation, money supply and commercial balance, do not help in predicting the short-term rates, but follow the theory of the *'random walk'*. According to Chinn and Meesl (1955) the aggregates help in predicting the long-term period.

Predictions for the exchange rates are more successful in medium and long term periods. The existing fluctuations in the exchange rates per day are essentially due to some unexpected circumstances and factors, such as a sudden and massive export / import goods. If for example a country produces and exports vegetables, during the season of their maturity, the exports are rising. This causes greater influx and exchange (foreign) money, which strengthens the domestic currency.

The exchange market is not only concerned with the present state of aggregates of a country but also with their future evolution. So, investors and other interested parties are obliged to examine any time announced something new about them, whether it is a situation of non-reversible and permanent or a temporary phenomenon, as well, and changes which will result in all aspects of economic activity.

Moreover, if changes in such areas produce almost always reactions both in the foreign exchange market and the policy of any government, it is necessary to further investigate them by using appropriate models.

Chapter 3

1. Data Research and Methodology

1.1. Data

The data which we will use in our analysis are those of the actual oil price Brent and the real exchange rate of Euro/Dollar. In our original intentions was to also research the impact of the real exchange rate with the real price of oil WTI, but as we found a very high correlation (99.6%) between Brent and WTI, as shown by the results in Table 1, we chose to use in this study only one of these two, namely the Brent, as this is the basis for calculating the price of 60% of the daily purchases and sales of oil carried in the global market.

We should mention, at this point, that for the purposes of this study, we had made logarithms both time series used, which consist of the daily observations for the period from 01/01/2001 up to 31/12/2007 in order to "*normalize*" our data. The rationale behind the choice of this particular period of time has to do both with the temporal substantial input of the Euro in the global economy and on a practical level, and secondly because this period begins to be emerged, through observation of empirical data, an inversion of the relationship of the parity of dollar and the oil price, as the hitherto research, like that of Amano and van Norden (1998), including prior periods, conclude that the relationship is directly proportional.

Finally the source of our data (nominal exchange rate, nominal oil price of Brent, US CPI and Eurozone CPI) is the site of DataStream.

Correlations

		London Brent U$/BBL Real Price	Crude Oil-WTI Spot Cushing U$/BBL REAL PRICE
London Brent U$/BBL Real Price	Pearson Correlation	1,000	,996**
	Sig. (2-tailed)		,000
	N	84,000	84
Crude Oil-WTI Spot Cushing U$/BBL REAL PRICE	Pearson Correlation	,996**	1,000
	Sig. (2-tailed)	,000	
	N	84	84,000

**. Correlation is significant at the 0.01 level (2tailed).

Table 1: *Correlations between the exchange rate of EUR/USD and crude oil*

In this table, we examine the correlation coefficient between two series which we want to use as dependent variables. The very high degree of correlation that exists between them, 99.6%, allows us to use in our research only one of the two series.

1.2. Methodology

In this survey, the methodology we will use follows this international literature. At the initial stage, it will include an estimation of the original regression and the first conclusions arising from this audit. We will proceed to the diagnostics of the model referring to the existence of heteroscedasticity and autocorrelation and if discern their existence, we are going to apply the prescribed in the literature actions in order to rid our sample of these two characteristics. In this way, we can no longer consider the assessors of our regression as reliable.

In the next stage, we will pass to the Unit Root Test, in order to ascertain the degree of integration of our series, but only after test any existence of structural breaks in our series. Where the results of the unit root test satisfy the conditions for the control of integration of the series, we will go to the Cointegration Test, in order to discern whether there is any long-term equilibrium relationship between our lines.

Afterwards, and under the condition that our series are cointegrated, we will proceed to carry out the Error Correction Model, in order to identify the short-term deviation from the long-term relationship of the equilibrium and the restore speed to it. In the last stage of our econometric control, we will investigate the existence and direction of causality between the rows, the relationship of which we are investigating.

The basic assumption we make is that the fall in the price of the Dollar against the Euro, through the consequences this has for the real incomes of the oil-producing countries and the possible investors' portion hedge holdings of dollars through the purchase of goods, has the effect of increasing the price of oil.

2. Empirical Results and Economic Interpretation from the Investigation of Oil Prices and the Exchange Rate

2.1. Introduction

In this chapter, we will investigate any causal relationship between the exchange rate EUR/USD and the price of oil. Our research aims to investigate whether the change in the exchange rate affects, and in which way, the price of oil. Through a simple observation of the current economic developments, hardly one could argue that these two variables, the exchange rate as an independent variable and the price of oil as dependent variable, are not related.

We are witnessing, especially during the last period of time, where historically high oil prices combined, even in the day level, with the historically low dollar against the euro. Therefore, in order to move from simple observation and theory, to the econometric testing and empirical results obtained from our research, we will use the basic econometric techniques used in the literature to argue about the relationship between our variables.

1.2. Checking the Initial Regression, Factor Assay and Correlation Coefficient

In the first stage of our research, we run the initial regression:

LROP = C (1) + C (2) * LRER (1) wherein

LROP is the logarithm of the Real Oil Price, C is a constant and LRER is the logarithm of the Real Exchange Rate Euro/Dollar.

The estimation of the regression, as shown in the table above is as follows:
LROP = 3,373080093-2,161639215 * LRER

In the same table, we observe that there is a fairly high R^2 = 63,4771%. Wherein R^2 , we called the Factor Assay in order to express the percentage of the variability of the dependent variable Y, which is interpreted by the independent variable X. This factor can take values in the interval [0,1]. The greater the value of R^2, the better the linear model reflects the data.

Dependent Variable: LROP

Method: Least Squares

Date: 03/01/16 Time: 22:08

Sample: 1 1826 included observations: 1825

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LRER	-2.161639	0.038403	-56.28849	0.0000
C	3.373080	0.006303	535.1457	0.0000

R-squared	0.634771	Mean dependent var	3.544098
Adjusted R-squared	0.634571	S.D. dependent var	0.390272
S.E. of regression	0.235922	Akaike info criterion	-0.049534
Sum squared resid	101.4669	Schwarz criterion	-0.043496
Log likelihood	47.19948	F-statistic	3168.394
Durbin-Watson stat	0.010153	Prob(F-statistic)	0.000000

Table 2: *Correlation Coefficient R*

Also, a significant factor that can identify and give the directions in our research is the correlation coefficient r, where in the rows we see that it takes the value r = -0.796725 (Table 2). The correlation coefficient is another measure of covariance which is also smoothed so that the range of values is limited to the interval [1, -1].

Since we have the overall expression of the covariance through the equation Cov (R a, R b) = $\rho_{ab} * \sigma_a * \sigma_\beta$ and after solving for ρ_{ab} , we have:

ρab = Cov (R a, R b) / $\sigma_a * \sigma_\beta$. The positive correlation coefficient indicates that the variables change in the same direction and the negative indicates that the variables change conversely.

	LRER	LROP
LRER	1.000000	-0.796725
LROP	-0.796725	1.000000

Table 3: *Estimating the Correlation Coefficient between the values of LROP and LRER.*

In our research, we have concluded to a negative correlation coefficient and indeed quite high, which suggests the opposite movement of our variables. If namely that one of the variables is moved positively by one unit, the other will adversely altered by 0.79 units.

1.3. Diagnostics Model

At this stage we will review our model for the existence of heteroscedasticity and autocorrelation, since the non - existence of these two characteristics are two of the main assumptions of the model of linear regression.

The first case to consider is that the variance is constant for all residuals, namely that there exists homoscedasticity.

In other words, Var (ut) = σ^2 for t = 1,2 ... n. The problem of the existence of heteroscedasticity, which was obvious in our model, had been overcome by adding a GARCH element (Generalized Autoregressive Conditional Heteroscedasticity) provided through the econometric package E-Views and taking the corellogram where the squared residuals in adjusted prices were controlled, we can accept the existence of homoscedasticity.

The second test, we are going to do, refers to the existence of the autocorrelation. We will examine whether the residuals of our model are uncorrelated. Therefore, we will use the function of the Durbin-Watson test. The price of control - function is estimated from the residuals of the regression d, compared with the lower and upper critical value d_L and d_u , respectively. This audit will be carried out through the E-Views program, knowing that a value of Durbin-Watson close to 2 is an issue for us, as it implies the absence of autocorrelation.

Since in the audit we had performed on the original series, we had a significant positive autocorrelation, we did the same control in Returns of the rows and we can now discern from the corellogram in Table 1 of the Annex that there no longer exists autocorrelation, with the only exception in the individual lags after the eighth.

In order to eliminate that even very small autocorrelation, we are going to add to our model an AR term to reach the point to completely eliminate the existence of autocorrelation of the residuals. In the corellogram in table 2 of the annex, it is apparent that the addition of the term AR (8) which was selected after repeated tests was helpful to reach the desired result, as the probability is greater than 0.05, value that is accepting the null hypothesis at a significance level 5% with non - auto correlated residuals.

Following our original model test procedure to the existence of heteroscedasticity and autocorrelation, and the corrective action that was necessary to do those appraisers of our regressions in order to be credible, we "*ran*" the new regression and the results are shown in Table 3 in the Annex.

1.4. Unit Root Test

In the next stage and before we move on to the Unit Root Test to test whether our series are characterized by stagnation or not, we will consider whether there are any structural break in our time series, with the simpler methods, this of the observation of the graphs generated by the prices of our observations.

This check is made because Perron (1989) showed that the presence of structural break which will not be taken into account, may lead to erroneous results of the Unit Root Test. In consideration of the graphs of the examined time series from us, it does not seem such a point, so we will consider as reliable the Unit Root Test we are going to conduct.

Then we move on to the Unit Root Test in order to test for the existence of a unit root in the time series since the data we use came from stationary processes, but knowing that most economic series are non-stationary. A time series is called stationary when the value oscillates around the medium, i.e. the values series takes the different time intervals with the same medium, the same variation and the value of the covariance between two periods only depends on the delay between these two time periods.

For the verification of this, we will use the ADF-test, through econometric E-Views program. Our null hypothesis is that the series is a unit root. The null hypothesis is true when the value t-statistics is less than the critical value of the ADF-test. Otherwise, ie when the value of t-statistics is larger than the critical value of the ADF-test, our null hypothesis is discarded. In case the stagnation of rows fails, we check whether taking the first differences of the series turned them into stagnant.

From the tables in ADF-test at prices we quote, it is clear that for our two series, LROP and LRER, we accept the null hypothesis, ie the existence of a unit root (Tables 3 and 4). Therefore, we take the first difference and repeat the testing. We see, now, in these two new tables we have formed, that the first differences of both our series are stationary, ie integral in first order, I (1).

Table 4: *Unit Root Test for the values of LRER*

Null Hypothesis: LRER has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic based on SIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.879729	0.6646
Test critical values:	1% level	-3.963084	
	5% level	-3.412275	
	10% level	-3.128070	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LRER)

Method: Least Squares

Date: 03/01/16 Time: 09:26

Sample (adjusted): 1/02/2001 12/31/2007

Included observations: 1823 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LRER(-1)	-0.003789	0.002016	-1.879729	0.0603
C	0.000367	0.000391	0.940029	0.3473
@TREND(1/01/2001)	-9.77E-07	5.50E-07	-1.776181	0.0759

R-squared	0.001966	Mean dependent var	-0.000226
Adjusted R-squared	0.000869	S.D. dependent var	0.005640
S.E. of regression	0.005638	Akaike info criterion	-7.517064
Sum squared resid	0.057845	Schwarz criterion	-7.508000
Log likelihood	6854.804	F-statistic	1.792179
Durbin-Watson stat	2.045302	Prob(F-statistic)	0.166891

Table 5: *Unit Root Test for values of LROP*

Null Hypothesis: LROP has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic based on SIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.234921	0.0779
Test critical values:	1% level	-3.963079	
	5% level	-3.412273	
	10% level	-3.128068	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LROP)

Method: Least Squares

Date: 03/01/16 Time: 09:31

Sample (adjusted): 1/02/2001 12/31/2007

Included observations: 1825 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LROP(-1)	-0.011509	0.003558	-3.234921	0.0012
C	0.033915	0.010421	3.254600	0.0012
@TREND(1/01/2001)	8.30E-06	2.63E-06	3.152089	0.0016

R-squared	0.005792	Mean dependent var	0.000706
Adjusted R-squared	0.004701	S.D. dependent var	0.021739
S.E. of regression	0.021688	Akaike info criterion	-4.822486
Sum squared resid	0.857001	Schwarz criterion	-4.813430
Log likelihood	4403.519	F-statistic	5.307276
Durbin-Watson stat	2.020685	Prob(F-statistic)	0.005032

Table 6: *Unit Root Test for the first degree differences of LRER*

Null Hypothesis: RRER has a unit root

Exogenous: None

Lag Length: 0 (Automatic based on SIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-43.68776	0.0001
Test critical values:	1% level	-2.566233	
	5% level	-1.940998	
	10% level	-1.616582	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RRER)

Method: Least Squares

Date: 03/01/16 Time: 09:32

Sample (adjusted): 1/03/2001 12/31/2007

Included observations: 1821 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RRER(-1)	-1.023340	0.023424	-43.68776	0.0000

R-squared	0.511883	Mean dependent var	8.81E-06
Adjusted R-squared	0.511883	S.D. dependent var	0.008076
		Akaike info criterion	-7.516574
S.E. of regression	0.005642	Schwarz criterion	-7.513550
Sum squared resid	0.057936	Durbin-Watson stat	2.000033
Log likelihood	6844.841		

Table 7: *Unit Root Test for the first degree differences of the values of LROP*

Null Hypothesis: RROP has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic based on SIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-43.65887	0.0001
Test critical values:	1% level	-3.433734	
	5% level	-2.862921	
	10% level	-2.567552	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RROP)

Method: Least Squares

Date: 03/01/16 Time: 11:11

Sample (adjusted): 3 1826

Included observations: 1824 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RROP(-1)	-1.019687	0.023356	-43.65887	0.0000
C	0.000680	0.000508	1.338340	0.1810

R-squared	0.511279	Mean dependent var	-5.38E-05
Adjusted R-squared	0.511011	S.D. dependent var	0.030999
S.E. of regression	0.021677	Akaike info criterion	-4.824019
Sum squared resid	0.856156	Schwarz criterion	-4.817979
Log likelihood	4401.506	F-statistic	1906.097
Durbin-Watson stat	2.003261	Prob(F-statistic)	0.000000

1.5. Integration Testing

In the chapter for the unit root test, we found that our series is integrated of first order I(1). That means that it is integrated at first differences and this was because we wanted to know that our data will not lead us to the problem of a spurious regression. This problem can occur in case of using non-stationary series and if the time series are highly correlated but be separated by a real relationship and that this is due to the existence of trends in both time series (Granger and Newbold, 1974).

In the next stage of our research, we will try to discern whether it exists or not a long-term equilibrium relationship between the levels of our time series and not at the level of first differences. We will return in our baseline and we are going to use monthly observations. The reason why we had made that choice is because the use of daily observations has a major drawback: although they are able to identify a possible relationship to short-term horizons, they are unable to make medium-term (Eurobank Research 2007 p. 10-12).

To control and detect whether it exists or not a long-term relationship in our series of levels, we will use the Cointegration Test. According to Engle and Granger (1987) for cointegration, the tested time series should not be nonstationary to their original levels and stationary in their first differences, which happens with the data of our research.

In this case our sequences can be cointegrated if there exists a linear combination between the rows that is stagnant, which would indicate a stable long linear relationship between them. This linear combination is called the cointegrating equation, which reflects the long-run equilibrium relationship between the rows. In short, the economic variables may have an independent path between them in the short level (that means they should not be non-stationary) but despite this, there may be a common long-term course, in case of integration, fact which should be seriously considered through specialization of the error correction, as we will see below.

The cointegration equation has the form: $Y_t = aX_t + U_t$. This linear combination is stationary, ie I(0) and as it was already mentioned the regression among the variables is expressed in real terms and not in first differences, in order to make sense and not be spurious even if the primary series is not stationary.

Generally speaking, if two or more non-stationary variables are of the same grade completed, supposing d, then we say that these cointegrated if there is a linear combination of them that is of grade b and if b <d, meaning that they are of the lesser degrees of integration.

Since we have found in our series that are integrated at the same class I (1) in first differences and nonstationary at the price level, we perform cointegration test.

The hypotheses that we check are:

H_o: No cointegration between variables.

H_L: There is cointegration between variables.

The control mode we chose to identify whether there exists or not the relationship of integration between our variables is the Johansen's cointegration test as it was carried through the econometric package of E-Views and the results of which are given in Table 7 confirm the existence of a relationship of cointegration between the variables.

We also observe the coefficient that gives us the control, given that an appreciation of the dollar by 1% results in a drop in oil prices at 1.176767%. This is in agreement of course with the simple observation of recent years in the foreign exchange market and the commodities market, where it is clear that these two lines are moving contrary.

Also important is the fact that this conclusion contradicts the hitherto citation as we had reviewed and where an increase in oil prices led to an appreciation of the dollar, thereby detecting a positive correlation between variables. At the same time the result enhances the potential, according to Benassy, Mignon and Penot (2005), for a reversal of this relationship, as it was originally and vaguely identified in their research.

Table 8: *Cointegration Test for LROP and LRER*

Johansen Cointegration Test

Date: 03/01/16 Time: 16:08 Sample (adjusted): 9 84

Included observations: 76 after adjustments

Trend assumption: Quadratic deterministic trend

Series: LNEUR LNBRENT Lags interval (in first differences): 1 to

Unrestricted Cointegration Rank Test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.257649	28.26181	18.39771	0.0015
At most 1 *	0.071266	5.618893	3.841466	0.0178

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.257649	22.64292	17.14769	0.0072
At most 1 *	0.071266	5.618893	3.841466	0.0178

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

LNEUR	LNBRENT
-10.62419	12.50221
17.21618	1.696514

Unrestricted Adjustment Coefficients (alpha):

D(LNEUR)	0.007696	-0.004029
D(LNBRENT)	-0.033441	-0.011292

1 Cointegrating Equation(s):	Log likelihood	283.2352

Normalized cointegrating coefficients (standard error in parentheses)

LNEUR	LNBRENT
1.000000	-1.176767
	(0.23983)

Adjustment coefficients (standard error in parentheses)

D(LNEUR)	-0.081759
	(0.02761)
D(LNBRENT)	0.355286
	(0.09791)

1.6. Error Correction Model

Following the identification of long-run equilibrium relationship between our variables, the next step is to assess the function between cointegrated variables based on the Error Correction Model. This model essentially identifies the short-term deviation from the long-term equilibrium. Engle and Granger (1987) show that in the case of two cointegrated variables, the short-term imbalance between the relationships can be expressed as an Error Correction Model (Granger Representation Theorem).

The model has features which both permit binding of variables to restrictions imposed under the long-term relationship balance to be satisfied and the other gives those margins in the short-term rates to move more flexibly and dynamically, so that the period t + 1 covering part of the imbalance of the period t, the t_2 this of t_1 so on, thereby incorporating short and long term effects on the system.

On Error Correction Model we will use our differences of variables, as defined in the literature, while the choice of lags was based on the Akaike criterion. We applied the model using 1 to 8 lags and in the end we chose the number of lags that gave us the lowest number in this test, while we included the factor of trend. The econometric package E-Views is chose again to execute the process of our model and its results are given in Table 8, which shows:

(LNeurt) = - 0,007026 + 0,130822 * (LNeurt-1) -0,025405 * (LNeurt-2) + 0,15597 * (LNbrentt-1) + 0,003633 * (LNbrentt-2) + 3,53 * 10-5 * t-0,014517 et.

Where (Lneur) is the change in the price of the exchange rate, (Lnbrent) the change in the price of oil and et the change of the error correction term.

It is also very important to note the Error Correction Term, as it is given through the Results of Error Correction Model we performed. According to Granger (1988), when the Error Correction Term within a VECM model is statistically significant, which happens in our survey, this proves the existence of causality between the variables. This factor explains a dynamic process that takes place to enable long relationship balance of our long-term lines, giving us the speed of adjustment to equilibrium.

In our testing, the speed of adjustment in the exchange rate is equal to 0.014517 per month, which means that each year the percentage adaptation of the series is equal to 17.4204%. Although we cannot characterize this as a particularly high speed, however, it is much higher than this mentioned in the research of Benassy, Mignon and Penot (2005), in which the annual adjustment of short-term imbalance in the long-term equilibrium occurs at 10.6488% annually.

Table 9: *Error Correction Model*

Vector Error Correction Estimates

Date: 03/01/16 Time: 15:45

Sample (adjusted): 4 84

Included observations: 81 after adjustments

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LNEUR(-1)	1.000000
LNBRENT(-1)	-1.811378
	(0.58392)
	[-3.10207]
@TREND(1)	0.033806
C	4.904285

Error Correction:	D(LNEUR)	D(LNBRENT)
CointEq1	-0.014517	0.114057
	(0.01226)	(0.04101)

	[-1.18424]	[2.78118]
D(LNEUR(-1))	0.130822	0.347816
	(0.11459)	(0.38337)
	[1.14162]	[0.90727]
D(LNEUR(-2))	-0.025405	0.288199
	(0.11488)	(0.38432)
	[-0.22114]	[0.74990]
D(LNBRENT(-1))	0.015597	0.123978
	(0.03397)	(0.11366)
	[0.45909]	[1.09082]
D(LNBRENT(-2))	0.003633	-0.140537
	(0.03405)	(0.11391)
	[0.10669]	[-1.23375]
C	-0.007026	0.004191
	(0.00562)	(0.01881)
	[-1.24957]	[0.22280]
@TREND(1)	3.53E-05	0.000317
	(0.00012)	(0.00039)
	[0.30626]	[0.82334]
R-squared	0.048926	0.165149

Adj. R-squared	-0.028188	0.097458
Sum sq. resids	0.042466	0.475281
S.E. equation	0.023955	0.080142
F-statistic	0.634459	2.439755
Log likelihood	190.9827	93.16710
Akaike AIC	-4.542782	-2.127583
Schwarz SC	-4.335855	-1.920655
Mean dependent	-0.005840	0.014299
S.D. dependent	0.023625	0.084358

Determinant resid covariance (dof adj.)	3.65E-06
Determinant resid covariance	3.04E-06
Log likelihood	284.5770
Akaike information criterion	-6.631531
Schwarz criterion	-6.158553

1.7. Checking the Granger Causality

In the last stage of our econometric research we will investigate the existence of any causal relationship and its direction between the two variables we used, ie the actual oil prices and the real exchange rate EUR / USD. This process aims to distinguish the true causal relationship, since a simple high correlation between these two variables does not mean necessarily a causal relationship between them. To address this difficulty, Granger (1969) was led to the Granger Causality. Theoretically, a variable X is a factor according to Granger for another variable Y if the historical information of X helps to have a better forecast of the path of the variable Y.

On the Granger test that we are going to perform, we will look at two null and two alternative hypotheses.

Ho: Rbrent not be a factor of Granger

H1: Rbrent is a factor of Granger

Ho: Reurusd not be a factor of Granger

H1: Reurusd not be a factor of Granger

The results, as shown in Table 13, prove that we cannot finally give an opinion on a link Granger causality for our variables.

Table 13: *Granger Causality Test*

Pairwise Granger Causality Tests

Date: 03/01/16 Time: 17:23

Sample: 1 84

Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
RBRENT does not Granger Cause REURUSD	82	0.59800	0.44165
REURUSD does not Granger Cause RBRENT		0.50647	0.47877

2. Empirical Investigation of Ganger Causality Between Exchange Rate Euro/USD and Gold Prices

The causal relationship between exchange rates and the gold price is sometimes confirmed and sometimes not, as shown by the conclusions reached by the various attempts of empirical and theoretical investigation of the existence of causality. It can be considered in this chapter, the enrichment of the existing findings from the different surveys to those resulting from the application of tests in the sample of the chosen data.

In this chapter, we are going to empirically investigate the causal link between the exchange rate between euro and dollar and the prices of gold, applying the linear Granger Causality Test.

According to the literature and the empirical studies, there could not exist a generalized conclusion on the existence or absence of a causal relationship between the two variables. Thus, the expected results from the survey follows have equal probability to converge in favor of acceptance of the original case or in favor of rejection.

The regression analysis is the statistical tool that utilizes the methodology for conducting tests of Granger causality. Specifically, the regression analysis determines the values of the estimators based on the method of least squares, from which the process occurs and the sum of squared residuals, which then serves to calculate the value of the statistical F and reach the conclusion of the audit.

All the observations that are included in the statistical analysis are the first differences of the observations of time series originally raised for recovery. The usefulness of such tactics is to minimize the sharp fluctuations' behaviors of these time series, whose observations, at times, show strong deviations from the average. These fluctuations are often responsible for the distortion of the quality and reliability of the control result.

2.1. The Results of the Tests for Granger Causality

After the detailed description of the methodology of Granger causality tests in the previous chapter we will explore the causal relationship between the exchange rate between euro and dollar and the price of gold. By applying the Granger causality tests, they will either verify or not, the theories and findings of previous empirical studies presented in chapter 1.

The analysis will focus on identifying the existence or the absence of Granger causal relationship between monthly gold price and the exchange rate of euro/dollar sampled of daily and monthly observations. The causality tests will be two-way (explore causal relationship from one variable to the other and vice versa) and apply in their entirety to the same study period.

We symbolize the variable of the exchange rate as EX_t and the variable of the price of gold as R_t, (which symbolizes the first differences) and following we will assess the null hypotheses:

Ho: R_t does not be a causal of Granger for the EX_t

Ho: EX_t does not be a causal of Granger for the R_t

The estimations for the aforementioned null hypotheses will be made by using the models described as follows (3.1) and (3.2),

$$Y_t = \mu_o + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-I} + u_t \qquad (3.1)$$

$$X_t = \varphi_o + \sum_{i=1}^{M} \gamma_i Y_{t-i} + \sum_{i=1}^{m} \delta_i X_{t-i} + e_t \qquad (3.2)$$

where m is the number of the lags.

and the limited forms that arise for $\beta_i = 0$ and $\gamma_i = 0$, respectively.

Specifically speaking, the forms to be taken by equations (3.1) and (3.2) for the purposes of this analysis, i.e. having as variables the EX_t exchange rate and the price of gold R_t, are:

$$EX_t = \mu_o + \sum_{i=1}^{m} \alpha_i \ EX_{t-i} + \sum_{i=1}^{m} \beta_i \ Rt\text{-}i + ut \tag{4.1}$$

$$EX_t = \mu_o + \sum_{i=1}^{m} \alpha_i \ EX_{t-i} + u_t \tag{4.2}$$

$$R_t = \varphi_o + \sum_{i=1}^{M} \gamma_i \ EX_{t-i} + \sum_{i=1}^{m} \delta_i \ Rt\text{-}i + et \tag{4.3}$$

$$R_t = \varphi_o + \sum_{i=1}^{M} \delta_i \ Rt\text{-}i + et \tag{4.4}$$

Applying the linear regressions to 5 lags for the sample of monthly observations and up to 8 lags for the sample of daily observations, we obtain the values for SSE and SSE*. SSE is the sum of squares of the residuals resulting from the estimation of the regression equation without limitations (4.1 and 4.3) and the SSE* is the sum of the squares of the residuals resulting from the estimation of equation with limitations (4.2 and 4.4). Then, on that basis and using the formula given in the previous chapter, we calculate the value of the statistical F, as follows:

$$F = \frac{\dfrac{SSE^* - SSE}{k}}{\dfrac{SSE}{n - 2k - 1}}$$

The Statistical F values which were resulted from the regressions of gold prices to the exchange rate and vice versa, are compared with the reviews of the F distribution with k, (n - 2k - 1) degrees of freedom.

In the tables below, we present in detail the results of the Granger causality test between the gold prices and the exchange rate. Each panel has controls for each rate separately and individually presented and discussed the results of the implementation of the checks on the sample of daily observations and separately sampled monthly observations.

Calculating the value of F - statistics for the two null hypotheses:

Ho: R_t does not be a causal of Granger for the EX_t and

Ho: EX_t does not be a causal of Granger for the R_t

Applying up to 5 lags for daily observations and up to 8 lags for monthly data and then comparing these values with the corresponding critical values of the F - distribution shows the result for rejecting or not the null hypothesis, as follows:

- ✓ If $F < F_0$, it is assumed that the variable R_t does not result in Granger causality for the EX_t of the function (4.1) or the variable EX_t is not caused of Granger of the R_t for the function (4.2).
- ✓ If $F > F_0$, we reject the hypothesis H_0 and we accept the H_1, that the R_t variable causes of Granger the EX_t for the function (4.1) or the variable EX_t causes of Granger the R_t for the function (4.2).

The F statistic follows the F - distribution with k and (n - 2k - 1) degrees of freedom:

$F \sim F(k, n - 2k - 1)$

Table 14: *Results from the Granger Causality Test between Gold Prices and Exchange Rate of Euro/Dollar (daily observations)*

n	**K (number of limitations)**	**SSE**	**SSE***	**F-statistics**	**F critical**	**Results from the test**
2963	1	1,88416	1,88419	0,05027	3,84000	Accept the H_0
2962	2	1,88294	1,88300	0,04947	3,00000	Accept the H_0
2961	3	1,88251	1,88258	0,03975	2,60000	Accept the H_0
2960	4	1,88156	1,88164	0,02823	2,37000	Accept the H_0
2959	5	1,88139	1,88153	0,04419	2,21000	Accept the H_0
2958	6	1,88116	1,88138	0,05792	2,10000	Accept the H_0
2957	7	1,88048	1,88093	0,10259	2,01000	Accept the H_0
2956	8	1,87994	1,88044	0,09771	1,94000	Accept the H_0

As it is apparent from the table above, the findings of investigating the existence of a causal link between the exchange rate and the price of gold, on the sample of the daily observations do not reveal the slightest indication of rejection of the null hypothesis.

The gold price does not be a causal for the exchange rate and respectively either the exchange rate does not be a causal for the gold price. The findings of these audits do not reject the existence of any kind of correlation between variables (for instance via a third variable) but a linear causal relationship.

Table 15: *Results from the Granger Causality Test between Gold Prices and Exchange Rate of Euro/Dollar (monthly observations)*

n	K (number of limitations)	SSE	SSE*	F-statistics	F critical	Results from the test
139	1	1,78936	1,79040	0,07950	3,84000	Accept the H_0
138	2	1,72060	1,72631	0,22057	3,00000	Accept the H_0
137	3	1,65752	1,66286	0,28081	2,60000	Accept the H_0
136	4	1,57555	1,60472	0,58793	2,37000	Accept the H_0
135	5	1,57507	1,60454	0,46400	2,21000	Accept the H_0

3. Empirical Analysis of the Impact from the Gold and Oil Prices on the Exchange Rate of Euro/Dollar

This analysis examines the relationship between gold and oil yields compared to the yields of the exchange rates of Euro/Dollar.

The analysis is based on the Generalized Autoregressive Conditional Heteroscedasticity Model (GARCH), and also on two variants of the model, EGARCH (Exponential GARCH) and TGARCH (Threshold GARCH).

One basic assumption of the linear regression is that the prices of the disrupting factor (errors) u_t are random variables distributed with mean zero and constant variance σ^2 for all values of t. Also, it is assumed that the prices of disrupting the term do not exhibit autocorrelation. That means that their covariance is zero and the explanatory variables are not stochastic. The hypothesis that the variance of disrupting term is stable is known as homoscedasticity. When the aforementioned does not exist, then, we can say that there is heteroscedasticity in the price of the disrupting factor, meaning that the random variables have a different variation.

Typically, the autocorrelation is a phenomenon that occurs in time series while heteroscedasticity occurs primarily in cross-sections. However, there are cases where heteroscedasticity appears when using time series in economic analysis. More specifically, heteroscedasticity occurs when the fluctuation of disrupting term price is a function of prices with a lag (Christou, 2007).

3.2. ARCH Model

The Autoregressive Conditional Heteroscedasticity Model (ARCH Model) is written, as follows:

$Y_t = \beta_1 + \beta_2 X_{2t} + \ldots + \beta_k X_{kt} + u_t, \quad u_t \sim N(0, \sigma_t^2)$

In the model, the fluctuation of the disrupting term is independent of the explanatory variables but changes over time and the change is related to how fickle the disturbance term in the recent past was. Therefore, it appears as the variance heteroscedasticity of the disrupting the term depends on the volatility of past prices. In its simplest form the variation of disrupting the term depends on the volatility of the residuals of the previous period,

where $\sigma_t^2 = \alpha_0 + \alpha_1 u^2_{t-1}$

That means that the variation (σ_t^2) of the disrupting term is a function of the constant (α_0) and the square of the value of the residuals of the previous period (u^2_{t-1}). The above relationship is called the conditional variance of the disrupting term (Christou, 2007; Brooks, 2008).

The model can be extended to a general form wherein the variation of the residuals depends on q lags of the squared residuals, i.e.,

$\sigma_t^2 = \alpha_0 + \alpha_1 u^2_{t-1} + \alpha_2 u^2_{t-2} + \ldots + \alpha_q u^2_{t-q}$

In the literature, rather than to use the term σ_t^2 for conditional variance term, it is used the h_t, whereby the model can be captured as follows:

$Y_t = \beta_1 + \beta_2 X_{2t} + \ldots + \beta_k X_{kt} + u_t, \quad u_t \sim N(0, \sigma_t^2)$
$h_t = \alpha_0 + \alpha_1 u^2_{t-1} + \alpha_2 u^2_{t-2} + \ldots + \alpha_q u^2_{t-q}$

3.3. GARCH Model

In the GARCH model, the conditional variance depends on the time lags. In relation $\sigma_t^2 = \alpha_0 + \alpha_1 u^2_{t-1} + \alpha_2 u^2_{t-2} + \ldots + \alpha_q u^2_{t-q}$ the conditional variance σ_t^2 is a function of lagged prices and takes the following form:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u^2_{t-1} + \alpha_2 u^2_{t-2} + \ldots + \alpha_q u^2_{t-q} + \beta_1\sigma^2_{t-1} + \\ + \beta_2\sigma^2_{t-2} + \ldots + \beta_p\sigma^2\ t\text{-}p$$

The above relation is the Generalized Autoregressive Conditional Heteroscedasticity (Christou, 2007). For large values of p and q which are difficult to assess in practice, the case is considered where q = p = 1, ie the model GARCH (1,1) and under the condition that the conditional variance is reflected as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u^2_{t-1} + \beta_1\sigma^2\ t\text{-}1$$

In the GARCH model, while the conditional variance changes, the fluctuation (unconditional variance) is constant and is given by:

$$\operatorname{var}(u_t) = \frac{\alpha_0}{1 - (\alpha_1 + \beta)}$$

wherein $a_1 + b < 1$.

- ✓ When $\alpha_1 + \beta \geq 1$, then the variance of u_t cannot be determined and is called "*non-stationary*" variation.
- ✓ When $\alpha_1 + \beta = 1$, then the variance of u_t is called "*unit root*" and the model is called "*integrated*» GARCH (Integrated GARCH or IGARCH) (Brooks, 2008).

3.4. TGARCH Model

The GARCH models assume that volatility behaves symmetrically to positive and negative shocks of the economy. However, it has been argued that a negative shock to the economy is likely to cause more volatility than a positive shock of the same magnitude creating asymmetry in returns of investment assets. GJR models or Threshold GARCH (TGARCH) and Exponential GARCH (EGARCH) are extensions of the GARCH model and consider the asymmetry of returns of investment assets in the positive and negative shock in the economy.

The GJR model is a simple extension of the model GARCH by adding an extra term to measure the possible asymmetry. The current fluctuation condition is derived as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u^2_{t-1} + \beta_1 \sigma^2_{t-1} + \gamma u^2_{t-1} I_{t-1}$$

where $I_{t-1} = 1$ if $u_{t-1} < 0$ and

where $I_{t-1} = 0$ if $u_{t-1} \geq 0$

The asymmetric term γ must be positive (γ > 0) in order to have a leverage effect and therefore asymmetry in returns. It is understood that an essential condition for the non - negativity of variance under this condition is applicable to the following:

$\alpha_0 > 0, \alpha_1 > 0, \beta_1 \geq 0,$ and $\alpha_1 + \gamma \geq 0$.

3.5. EGARCH Model

The Exponential GARCH model is a further extension of the model GARCH presenting significant advantages. The conditional variance is of the form:

$$\ln(\sigma_t^2) = \omega + \beta \ln(\sigma_{t-1}^2) + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha \left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right]$$

Because of the use of the logarithm of the conditional variance, even when the individual parameters are negative, the conditional variance is positive. Also, if the relationship between volatility and performance is negative, the coefficient γ would also be negative (γ <0) (Brooks, 2008).

3.6. Data Analysis

In order to investigate as fully as possible the countervailing role of the gold and the crude oil over the exchange rate of euro and dollar, we created a model. In this model, the yield of gold and oil were used as the independent variables, while yields of the exchange rates as dependent.

3.7. Presentation of Results

Following the research, we show a detailed presentation of the empirical results. In particular, we present the results tables for the models created. Specifically, we present two sub-tables:

- ✓ The first table shows the values of Log Likelihood (Llik), Akaike Criterion (AIK) and Schwarz Criterion (BIC) of the GARCH, EGARCH and TGARCH models.
- ✓ The second table shows the values of the coefficients rates, the prices of standard deviations (standard errors), the statistical significance and the values of the coefficients a_0, a_1 and b_1 for the GARCH model, the values of the coefficients ω, a, γ and b for the EGARCH model and the values of the coefficients a_0, a_1, b_1 and γ for the TGARCH model.

Note 1: The standard deviations of the rates are shown in the brackets below the values of the rates.

Note 2: The statistical significance of the coefficients is indicated by using asterisks near the values of them. The three asterisks indicate statistical significance of 1% level, two asterisks statistical significance level of 5% and an asterisk statistical of 10% level of significance. The rates which are not accompanied by asterisks are not statistically significant.

Table 16: *Results from Llik, AIK, BIC, scenario 1*

Scenario 1	GARCH	EGARCH	TGARCH

Yields of Gold and Silver			
Log - Likelihood (Llik)	4580,568	4590,959	4583,323
Akaike Criterion (AIC)	-5,450349	-5,461536	-5,452439
Schwarz Criterion (BIC)	-5,434191	-5,442146	5,433050
Yields of Gold and Oil			
Log - Likelihood (Llik)	3849,268	3500,924	3499,299
Akaike Criterion (AIC)	-5,101418	-5,117019	-5,114640
Schwarz Criterion (BIC)	-5,094267	-5,094092	-5,091713
Yields of Gold and Dow Jones			
Log - Likelihood (Llik)	4109,430	4123,524	4115,378
Akaike Criterion (AIC)	-4,889136	-4,904734	-4,895030
Schwarz Criterion (BIC)	-4,872978	-4,885344	-4,875640
Yields of Gold and Nasdaq			
Log - Likelihood (Llik)	4106,990	4120,590	4113,253
Akaike Criterion (AIC)	-4,886230	-4,901239	-4,892499
Schwarz Criterion (BIC)	-4,870071	-4,881849	-4,873109
Yields of Gold and S&P500			
Log - Likelihood (Llik)	4108,451	4123,524	4114,475
Akaike Criterion (AIC)	-4,887971	-4,904734	-4,893955
Schwarz Criterion (BIC)	-4,871812	-4,885344	-4,874565
Yields of Gold and EUR/USD			
Log - Likelihood (Llik)	1657,503	1664,209	1663,648
Akaike Criterion (AIC)	-4,810781	-4,827391	-4,825757
Schwarz Criterion (BIC)	-4,777794	-4,787808	-4,786174

Table 17: *Results of Llik, AIK, BIC, scenario 2*

Scenario 2	GARCH	EGARCH	TGARCH
Yields of Gold, Silver and Oil			
Log - Likelihood (Llik)	3799,748	3809,952	3805,402
Akaike Criterion (AIC)	-5,554536	-5,568011	-5,561350
Schwarz Criterion (BIC)	-5,531609	-5,541263	-5,534602
Yields of gold, Silver and Dow Jones			
Log - Likelihood (Llik)	4584,651	4594,341	4586,889
Akaike Criterion (AIC)	-5,454022	-5,464373	-5,455497
Schwarz Criterion (BIC)	-5,434632	-5,441751	-5,432875
Yields of Gold, Silver and Nasdaq			
Log - Likelihood (Llik)	4582,207	4591,967	4584,496
Akaike Criterion (AIC)	-5,451110	-5,461546	-5,452645
Schwarz Criterion (BIC)	-5,431720	-5,438924	-5,430024
Yields of Gold, Silver and S&P500			
Log - Likelihood (Llik)	4583,999	4593,519	4586,154
Akaike Criterion (AIC)	-5,453244	-5,463394	-5,454620
Schwarz Criterion (BIC)	-5,433855	-5,440773	-5,431999
Yields of Gold, Silver and EUR/USD			
Log - Likelihood (Llik)	1813,488	1816,889	1814,912
Akaike Criterion (AIC)	-5,261975	-5,268964	-5,263208
Schwarz Criterion (BIC)	-5,222391	-5,222783	-5,217027

Table 18: *Results from Llik, AIK, BIC, scenario 3*

Scenario 3	GARCH	EGARCH	TGARCH

Yields of Gold, Oil and Dow Jones			
Log - Likelihood (Llik)	3495,291	3507,746	3504,403
Akaike Criterion (AIC)	-5,108772	-5,125543	-5,120648
Schwarz Criterion (BIC)	-5,085845	-5,098795	-5,093900
Yields of Gold, Oil and Nasdaq			
Log - Likelihood (Llik)	3489,915	3502,077	3499,685
Akaike Criterion (AIC)	-5,100900	-5,117244	-5,113740
Schwarz Criterion (BIC)	-5,077973	-5,090496	-5,086993
Yields of Gold, Oil and S&P500			
Log - Likelihood (Llik)	3493,665	3505,749	3502,807
Akaike Criterion (AIC)	-5,106391	-5,122619	-5,118312
Schwarz Criterion (BIC)	-5,083465	-5,095872	-5,091564
Yields of Gold, Oil and EUR/USD			
Log - Likelihood (Llik)	1663,967	1670,019	1669,913
Akaike Criterion (AIC)	-4,826687	-4,841396	-4,841085
Schwarz Criterion (BIC)	-4,787104	-4,795215	-4,794904

Table 19: *Results of the variables values of scenario 1*

Scenario 1

Yields of Gold and Silver

	constant	**Silver**	**a_0**	**a_1**	**b_1**	**ω**	**a**	**γ**	**b**	**$a_1 + b_1$**
GARCH	0,000183	0,338845 ***	$9,54e^{-6}$ ***	0,138461 ***	0,837302 ***					0,975763 < 1
	[0,000340]	[0,005552]	[$1,54e^{-6}$]	[0,011814]	[0,012091]					
EGARCH	0,000387	0,329114 ***				-0,675433 ***	0,295349 ***	0,046492 ***	0,945388 ***	
	[0,000347]	[0,005420]				[0,064224]	[0,020652]	[0,013407]	[0,007194]	
TGARCH	0,000349	0,331075 ***	$1,02e^{-5}$ ***	0,172957 ***	0,833549 ***			-0,067570 ***		1,006506 > 1
	[0,000537]	[0,005586]	[$1,55e^{-6}$]	[0,015550]	[0,012654]			[0,021802]		

Yields of Gold and Oil

	constant	**Oil**	**a_0**	**a_1**	**b_1**	**ω**	**a**	**γ**	**b**	**$a_1 + b_1$**
GARCH	-0,000113	0,053353 ***	$8,67e^{-6}$ ***	0,143343 ***	0,847391 ***					0,990734 < 1
	[0,000428]	[0,011186]	[$2,41e^{-6}$]	[0,011638]	[0,013969]					
EGARCH	0,000404	0,045381 ***				-0,590111 ***	0,288682 ***	0,082448 ***	0,953760 ***	
	[0,000438]	[0,010992]				[0,066234]	[0,018204]	[0,012510]	[0,007493]	
TGARCH	0,000433	0,050652 ***	$1,09e^{-5}$ ***	0,203239 ***	0,841878 ***			-0,125985 ***		1,045117 > 1
	[0,000446]	[0,011276]	[$2,32e^{-6}$]	[0,018088]	[0,014819]			[0,020827]		

Yields of Gold and Dow Jones

	constant	**Dow Jones**	**a_0**	**a_1**	**b_1**	**ω**	**a**	**γ**	**b**	**$a_1 + b_1$**
GARCH	-0,000122	-0,047781 ***	$7,92e^{-6}$ ***	0,143654 ***	0,851207 ***					0,994861 < 1
	[0,000402]	[0,018142]	[$1,86e^{-6}$]	[0,011232]	[0,010841]					
EGARCH	0,000276	-0,054001 ***				-0,440680 ***	0,267150 ***	0,057096 ***	0,969666 ***	
	[0,000422]	[0,017690]				[0,040505]	[0,017013]	[0,010967]	[0,004597]	
TGARCH	0,000247	-0,043669 **	$8,45e^{-6}$ ***	0,183562 ***	0,850988 ***			-0,083332 ***		1,034550 > 1
	[0,000427]	[0,017673]	[$1,85e^{-6}$]	[0,015535]	[0,011714]			[0,018134]		

Yields of Gold and Nasdaq

	constant	Nasdaq	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	-0,000201	-0,010575	$8{,}00e^{-6}$ ***	0,141045 ***	0,853033 ***					0,994078 < 1
	[0,000404]	**[0,014812]**	**[$1{,}87e^{-6}$]**	**[0,010643]**	**[0,010442]**					
EGARCH	$9{,}83e^{-5}$	-0,013203				-0,442857 ***	0,264811 ***	0,056294 ***	0,969199 ***	
	[0,000425]	[0,014093]				[0,040293]	[0,016375]	[0,010726]	[0,004595]	
TGARCH	0,000182	-0,007922	$8{,}72e^{-6}$ ***	0,181315 ***	0,852405 ***			-0,084279 ***		1,033720 > 1
	[0,000430]	[0,014272]	[$1{,}85e^{-6}$]	[0,015022]	[0,011493]			[0,017804]		

Yields of Gold and S&P500

	constant	S&P500	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	-0,000150	-0,039237 **	$7{,}83e^{-6}$ ***	0,142492 ***	0,852364 ***					0,994856 < 1
	[0,000402]	[0,018688]	[$1{,}84e^{-6}$]	[0,011093]	[0,010702]					
EGARCH	0,000276	-0,054001 ***				-0,440680 ***	0,267150 ***	0,057096 ***	0,969666 ***	
	[0,000422]	[0,017690]				[0,040505]	[0,017013]	[0,010967]	[0,004597]	
TGARCH	0,000220	-0,034650 *	$8{,}47e^{-6}$ ***	0,182595 ***	0,851750 ***			-0,083448 ***		1,034345 > 1
	[0,000427]	[0,018144]	[$1{,}84e^{-6}$]	[0,015481]	[0,011636]			[0,018077]		

Yields of Gold and EUR/USD	constant	EUR/USD	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	0,001326	0,657199 ***	$3,60e^{-5}$ ***	0,179188 ***	0,762861 ***					0,942049 < 1
	[0,000692]	[0,051941]	[$1,05e^{-5}$]	[0,025336]	[0,035415]					
EGARCH	0,002568 ***	0,646896 ***				-0,701037 ***	0,308736 ***	0,114010 ***	0,939526 ***	
	[0,000669]	[0,049156]				[0,139450]	[0,034223]	[0,022532]	[0,016441]	
TGARCH	0,002147 ***	0,645754 ***	$2,95e^{-5}$ ***	0,265672 ***	0,777880 ***			-0,171059 ***		1,043552 > 1
	[0,000726]	[0,049893]	[$9,11e^{-6}$]	[0,043431]	[0,033259]			[0,044644]		

Table 20: *Results for the variables values, scenario 2*

Scenario 2

Yields of Gold, Silver and Oil

	constant	Silver	Oil	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	0,000142	0,281457 ***	0,015021	$7,66e^{-6}$ ***	0,162717 ***	0,825342 ***					0,988059 < 1
	[0,000358]	[0,005723]	[0,009237]	[$1,79e^{-6}$]	[0,014269]	[0,015794]					
EGARCH	0,000526	0,278505 ***	0,006995				-0,772488 ***	0,340266 ***	0,072059 ***	0,938588 ***	
	[0,000364]	[0,005557]	[0,008475]				[0,088741]	[0,022559]	[0,014260]	[0,009724]	
TGARCH	0,000439	0,273349 ***	0,013316	$8,18e^{-6}$ ***	0,215135 ***	0,824369 ***			-0,109871 ***		1,039504 > 1
	[0,000370]	[0,005226]	[0,009342]	[$1,75e^{-6}$]	[0,020041]	[0,016273]			[0,023600]		

Yields of Gold, Silver and Dow Jones

	constant	Silver	Dow Jones	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	0,000303	0,338543 ***	-0,046159 ***	$9,81e^{-6}$ ***	0,141110 ***	0,834005 ***					0,975115 < 1
	[0,000344]	[0,005443]	[0,013608]	[$1,55e^{-6}$]	[0,012272]	[0,013608]					
EGARCH	0,000580	0,328477 ***	-0,043249 ***				-0,686249 ***	0,301200 ***	0,044570 ***	0,944555 ***	
	[0,000351]	[0,005452]	[0,013343]				[0,065301]	[0,021267]	[0,013471]	[0,007293]	
TGARCH	0,000446	0,331608 ***	-0,043223 ***	$1,03e^{-5}$ ***	0,173098 ***	0,830856 ***			-0,061993 ***		1,003954 > 1
	[0,000359]	[0,005550]	[0,013576]	[$1,56e^{-6}$]	[0,015774]	[0,012985]			[0,022058]		

Yields of Gold, Silver and Nasdaq

	constant	Silver	Nasdaq	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	0,000237 ***	0,339392 ***	-0,022041 **	$9,62e^{-6}$ ***	0,138213 ***	0,837104 ***					0,975317 < 1
	[0,000342]	[0,005540]	[0,011132]	[$1,55e^{-6}$]	[0,011851]	[0,012243]					
EGARCH	0,000430	0,329470 ***	-0,015682				-0,676952 ***	0,296732 ***	0,044319 ***	0,945312 ***	
	[0,000345]	[0,005536]	[0,010906]				[0,065200]	[0,020833]	[0,013437]	[0,007285]	
TGARCH	0,000385	0,332250 ***	-0,018559 *		0,169706 ***	0,834118 ***			-0,061997 ***		1,003824 > 1
	[0,000358]	[0,005671]	[0,010991]	[$1,55e^{-6}$]	[0,015376]	[0,012716]			[0,021748]		

Yields of Gold, Silver and S&P500

	constant	Silver	S&P500	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	0,000287	0,339066 ***	-0,043441 ***	$9{,}74e^{-6}$ ***	0,139794 ***	0,835317 ***					0,975111 < 1
	[0,000342]	[0,005497]	[0,014156]	[$1{,}55e^{-6}$]	[0,012068]	[0,012383]					
EGARCH	0,000552	0,328394 ***	-0,040229 ***				-0,683324 ***	0,300399 ***	0,044028 ***	0,944850 ***	
	[0,000347]	[0,005511]	[0,013962]				[0,065248]	[0,021150]	[0,013441]	[0,007284]	
TGARCH	0,000427	0,332218 ***	-0,039481 ***	$1{,}03e^{-5}$ ***	0,170980 ***	0,832235 ***			-0,060645 ***		1,003215 > 1
	[0,000358]	[0,005633]	[0,014100]	[$1{,}55e^{-6}$]	[0,015536]	[0,012825]			[0,021910]		

Yields of Gold, Silver and EUR/USD

	constant	Silver	EUR/USD	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	0,001226	0,314137 ***	0,378449 ***	$4{,}11e^{-5}$ ***	0,166732 ***	0,718591 ***					0,885323 < 1
	[0,000656]	[0,012070]	[0,046660]	[$1{,}13e^{-5}$]	[0,026425]	[0,049351]					
EGARCH	0,001504 **	0,313154 ***	0,376059 ***				-1,573029 ***	0,331310 ***	0,081033 **	0,836511 ***	
	[0,000662]	[0,012939]	[0,044500]				[0,339493]	[0,051925]	[0,032101]	[0,039830]	
TGARCH	0,001469 **	0,310992 ***	0,375960 ***	$5{,}07e^{-5}$ ***	0,224349 ***	0,686237 ***			-0,119117 **		0,910586 < 1
	[0,000680]	[0,012163]	[0,046593]	[$1{,}35e^{-5}$]	[0,039714]	[0,060054]			[0,053257]		

Table 21: *Results from the variables values of scenario 3*

Scenario 3

Yields of Gold, Oil and Dow Jones

	constant	Oil	Dow Jones	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	$3{,}00e^{-5}$	0,052999 ***	-0,072672 ***	$8{,}55e^{-6}$ ***	0,148298 ***	0,843864 ***					0,992162 < 1
	[0,000424]	[0,010914]	[0,018858]	[$2{,}41e^{-6}$]	[0,012541]	[0,014480]					
EGARCH	0,000562	0,047902 ***	-0,078182 ***				-0,596516 ***	0,299161 ***	0,078806 ***	0,953934 ***	
	[0,000439]	[0,011078]	[0,018109]				[0,070080]	[0,019386]	[0,012979]	[0,007967]	
TGARCH	0,000525	0,050562 ***	-0,065948 ***	$1{,}02e^{-5}$ ***	0,206360 ***	0,840267 ***			-0,122688 ***		1,046627 > 1
	[0,000442]	[0,010987]	[0,018313]	[$2{,}37e^{-6}$]	[0,018387]	[0,014784]			[0,021315]		

Yields of Gold, Oil and Nasdaq

	constant	Oil	Nasdaq	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	$-7{,}60e^{-5}$	0,053153 ***	-0,017471	$8{,}54e^{-6}$ ***	0,142781 ***	0,848344 ***					0,991125 < 1
	[0,000429]	[0,011157]	[0,015359]	[$2{,}40e^{-6}$]	[0,011665]	[0,013865]					
EGARCH	0,000544	0,045702 ***	-0,022590 *				-0,587625 ***	0,289949 ***	0,081333 ***	0,954119 ***	
	[0,000430]	[0,010887]	[0,013602]				[0,067868]	[0,018442]	[0,012556]	[0,007729]	
TGARCH	0,000448	0,050487 ***	-0,012979	$1{,}07e^{-5}$ ***	0,202654 ***	0,842420 ***			-0,124629 ***		1,045074 > 1
	[0,000447]	[0,011215]	[0,014390]	[$2{,}35e^{-6}$]	[0,018009]	[0,014768]			[0,020772]		

Yields of Gold, Oil and S&P500

	constant	Oil	S&P500	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	$3{,}50e^{-6}$	0,053376 ***	-0,064368 ***	$8{,}31e^{-6}$ ***	0,145502 ***	0,846884 ***					0,992386 < 1
	[0,000425]	[0,010963]	[0,019524]	[$2{,}36e^{-6}$]	[0,012232]	[0,014129]					
EGARCH	0,000635	0,047146 ***	-0,063251 ***				-0,595420 ***	0,296949 ***	0,080952 ***	0,953790 ***	
	[0,000430]	[0,010926]	[0,018257]				[0,069116]	[0,019118]	[0,012817]	[0,007855]	
TGARCH	0,000495	0,050839 ***	-0,056087 ***	$1{,}02e^{-5}$ ***	0,204277 ***	0,841669 ***			-0,122100 ***		1,045946 > 1
	[0,000443]	[0,011046]	[0,018765]	[$2{,}34e^{-6}$]	[0,018216]	[0,014698]			[0,021054]		

Yields of Gold, Oil and EUR/USD

	constant	Oil	EUR/USD	a_0	a_1	b_1	ω	a	γ	b	$a_1 + b_1$
GARCH	0,001082	0,063762 ***	0,638670 ***	$3{,}96e^{-5}$ ***	0,182484 ***	0,751347 ***					0,933831 < 1
	[0,000695]	[0,019599]	[0,054002]	[$1{,}12e^{-5}$]	[0,024864]	[0,037158]					
EGARCH	0,002254 ***	0,057200 ***	0,640915 ***				-0,788608 ***	0,319689 ***	0,117870 ***	0,929227 ***	
	[0,000711]	[0,016456]	[0,047974]				[0,155653]	[0,034263]	[0,023258]	[0,018443]	
TGARCH	0,001885 ***	0,059943 ***	0,631051 ***	$3{,}21e^{-5}$ ***	0,268225 ***	0,770021 ***			-0,172516 ***		1,038246 > 1
	[0,000731]	[0,018823]	[0,051111]	[$9{,}46e^{-6}$]	[0,043343]	[0,034028]			[0,045303]		

Conclusions

Initially, we conclude that gold is a strong countervailing factor against the dollar. The metal apparently compensates for yield losses of investors resulting from the depreciation of the dollar against major currencies, such as euro. Indeed, the exchange rate EUR / USD seems to affect more changes in the performance of gold compared to the other rates and other economic variables.

In addition, gold works hedging against the returns of stock market indices, especially the Dow Jones index and Standard and Poor's 500, and shows greater statistical significance. The intensity of the compensation varies depending on the test stock index. The economic significance of the performance indices in shaping the gold price is less important than the importance of exchange rates. Generally, we can conclude that the odds of gold partially offset the loss in yields caused by falls in stock indices examined.

Also, regarding purchases of the silver and oil goods, yields of gold are moving in the same direction as the odds of silver. Therefore, there is no hedging of gold yields compared with the yields of silver. Meanwhile, oil yields also follow simultaneous movement with those of the precious metal and no apparent hedging relationship between these two economic variables.

In summary, gold operates hedging in relation to the performance of stock indices and compared to the trend in the dollar rate against the euro currency. The compensatory capacity towards the stock markets is limited. By contrast, compensatory ability towards dollar depreciation is much sharper both in statistical and economic significance.

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Annex

Correlogram of Standardized Residuals
Date: 03/01/16 Time: 09:46
Sample: 2 1826
Included observations: 1825

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC Q-Stat</th><th>Prob</th></tr>
<tr><td>| |</td><td>| |</td><td>1</td><td>-0.020</td><td>-0.0200.7386</td><td>0.390</td></tr>
<tr><td>| |</td><td>| |</td><td>2</td><td>0.033</td><td>0.0332.7526</td><td>0.253</td></tr>
<tr><td>| |</td><td>| |</td><td>3</td><td>0.021</td><td>0.0223.5694</td><td>0.312</td></tr>
<tr><td>| |</td><td>| |</td><td>4</td><td>0.010</td><td>0.0103.7644</td><td>0.439</td></tr>
<tr><td>| |</td><td>| |</td><td>5</td><td>0.007</td><td>0.0063.8451</td><td>0.572</td></tr>
<tr><td>| |</td><td>| |</td><td>6</td><td>-0.053</td><td>-0.0548.9188</td><td>0.178</td></tr>
<tr><td>| |</td><td>| |</td><td>7</td><td>0.037</td><td>0.03411.412</td><td>0.122</td></tr>
<tr><td>| |</td><td>| |</td><td>8</td><td>-0.056</td><td>-0.05217.256</td><td>0.028</td></tr>
<tr><td>| |</td><td>| |</td><td>9</td><td>0.037</td><td>0.03619.814</td><td>0.019</td></tr>
<tr><td>| |</td><td>| |</td><td>10</td><td>0.008</td><td>0.01319.945</td><td>0.030</td></tr>
<tr><td>| |</td><td>| |</td><td>11</td><td>-0.016</td><td>-0.01620.418</td><td>0.040</td></tr>
<tr><td>| |</td><td>| |</td><td>12</td><td>0.004</td><td>-0.00120.443</td><td>0.059</td></tr>
<tr><td>| |</td><td>| |</td><td>13</td><td>0.024</td><td>0.02821.530</td><td>0.063</td></tr>
<tr><td>| |</td><td>| |</td><td>14</td><td>0.018</td><td>0.01322.154</td><td>0.076</td></tr>
<tr><td>| |</td><td>| |</td><td>15</td><td>0.029</td><td>0.03623.668</td><td>0.071</td></tr>
<tr><td>| |</td><td>| |</td><td>16</td><td>-0.011</td><td>-0.01623.884</td><td>0.092</td></tr>
<tr><td>| |</td><td>| |</td><td>17</td><td>0.006</td><td>0.00423.959</td><td>0.121</td></tr>
<tr><td>| |</td><td>| |</td><td>18</td><td>-0.006</td><td>-0.00624.019</td><td>0.154</td></tr>
<tr><td>| |</td><td>| |</td><td>19</td><td>-0.027</td><td>-0.02825.408</td><td>0.148</td></tr>
<tr><td>| |</td><td>| |</td><td>20</td><td>-0.037</td><td>-0.03727.973</td><td>0.110</td></tr>
<tr><td>| |</td><td>| |</td><td>21</td><td>-0.002</td><td>0.00427.981</td><td>0.141</td></tr>
<tr><td>| |</td><td>*| |</td><td>22</td><td>-0.056</td><td>-0.05833.798</td><td>0.052</td></tr>
<tr><td>| |</td><td>| |</td><td>23</td><td>-0.021</td><td>-0.01734.597</td><td>0.057</td></tr>
<tr><td>| |</td><td>| |</td><td>24</td><td>-0.014</td><td>-0.01534.959</td><td>0.069</td></tr>
<tr><td>| |</td><td>| |</td><td>25</td><td>-0.002</td><td>0.00034.967</td><td>0.089</td></tr>
<tr><td>| |</td><td>| |</td><td>26</td><td>0.014</td><td>0.01535.351</td><td>0.104</td></tr>
<tr><td>| |</td><td>| |</td><td>27</td><td>0.009</td><td>0.01035.492</td><td>0.127</td></tr>
<tr><td>| |</td><td>| |</td><td>28</td><td>0.008</td><td>-0.00135.620</td><td>0.153</td></tr>
<tr><td>| |</td><td>| |</td><td>29</td><td>-0.038</td><td>-0.03438.257</td><td>0.117</td></tr>
<tr><td>| |</td><td>| |</td><td>30</td><td>0.014</td><td>0.00438.624</td><td>0.134</td></tr>
<tr><td>| |</td><td>| |</td><td>31</td><td>-0.035</td><td>-0.03140.896</td><td>0.110</td></tr>
<tr><td>| |</td><td>| |</td><td>32</td><td>-0.044</td><td>-0.04144.432</td><td>0.071</td></tr>
<tr><td>| |</td><td>| |</td><td>33</td><td>-0.017</td><td>-0.01545.000</td><td>0.079</td></tr>
<tr><td>| |</td><td>| |</td><td>34</td><td>-0.006</td><td>0.00145.065</td><td>0.097</td></tr>
<tr><td>| |</td><td>| |</td><td>35</td><td>0.005</td><td>0.00945.121</td><td>0.118</td></tr>
<tr><td>*| |</td><td>| |</td><td>36</td><td>-0.058</td><td>-0.05251.463</td><td>0.046</td></tr>
</table>

Table 1: *Correlogram of Standardized Residuals*

Correlogram of Standardized Residuals
Date: 03/01/16 Time: 22:49
Sample: 10 1826
Included observations: 1817
Q-statistic probabilities adju
for 1 ARMA term(s)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.007	-0.007	0.0825	0.521
		2	-0.012	-0.012	0.3442	0.557
		3	0.024	0.024	1.4036	0.496
		4	0.021	0.022	2.2336	0.525
		5	0.010	0.011	2.4039	0.662
		6	0.020	0.020	3.1269	0.680
		7	-0.007	-0.008	3.2223	0.780
		8	-0.010	-0.011	3.4075	0.845
		9	-0.005	-0.006	3.4474	0.903
		10	0.005	0.004	3.4983	0.941
		11	-0.010	-0.009	3.6687	0.961
		12	-0.017	-0.017	4.2064	0.963
		13	-0.016	-0.016	4.6845	0.968
		14	0.011	0.011	4.9104	0.977
		15	-0.026	-0.025	6.1322	0.963
		16	-0.007	-0.006	6.2156	0.976
		17	-0.015	-0.015	6.6091	0.980
		18	-0.019	-0.017	7.2413	0.980
		19	0.004	0.004	7.2638	0.988
		20	0.009	0.009	7.4118	0.992
		21	-0.006	-0.004	7.4822	0.995
		22	0.004	0.005	7.5112	0.997
		23	-0.020	-0.020	8.2468	0.996
		24	-0.009	-0.010	8.3938	0.998
		25	-0.018	-0.020	9.0181	0.998
		26	-0.012	-0.013	9.3043	0.998
		27	0.011	0.012	9.5353	0.999
		28	0.028	0.028	10.979	0.997
		29	-0.038	-0.035	13.582	0.990
		30	0.000	-0.001	13.582	0.993
		31	-0.021	-0.024	14.403	0.993
		32	-0.013	-0.014	14.732	0.994
		33	0.022	0.020	15.601	0.993
		34	0.019	0.019	16.291	0.993
		35	0.025	0.029	17.457	0.992
		36	0.010	0.010	17.650	0.994

Table 2: *Correlogram of Standardized Residuals*

Dependent Variable: RROP
Method: ML - ARCH
Date: 03/01/16 Time: 16:32
Sample (adjusted): 10 1826
Included observations: 1817 after adjustments
Convergence achieved after 14 iterations
Variance backcast: ON
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000934	0.000455	2.052443	0.0401
RRER	-0.380402	0.076131	-4.996680	0.0000
AR(8)	-0.053246	0.024527	-2.170917	0.0299
	Variance Equation			
C	1.74E-05	4.67E-06	3.719116	0.0002
RESID(-1)^2	0.053828	0.006160	8.738276	0.0000
GARCH(-1)	0.907423	0.013833	65.59734	0.0000

R-squared	0.084371	Mean dependent var	0.000618
Adjusted R-squared	0.065165	S.D. dependent var	0.021676
S.E. of regression	0.021550	Akaike info criterion	-4.902130
Sum squared resid	0.841009	Schwarz criterion	-4.883952
Log likelihood	4459.585	F-statistic	185.1187
Durbin-Watson stat	2.050616	Prob(F-statistic)	0.000080

Inverted AR Roots	.64+.27i	.64-.27i	.27-.64i	.27+.64i
	-.27+.64i	-.27-.64i	-.64-.27i	-.64+.27i

Table 3: *Least Squares in the Last Procedure of Regression*